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THE FUNCTIONALIZATION OF FIBRE MATERIAL SURFACES FOCUSED ON ELECTRICAL PROPERTIES

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ABSTRACT: The paper deals with the functionalization of fibre material surfaces, namely polyethylene-terephthalate (PET) and polypropylene (PP) fabrics by focusing pigmentation on electrical properties. Original PET and PP fabrics showed a high degree of electrical volume and surface resistance, as well as the accumulation of an electrostatic charge with a high half-time of discharge. After surface reformation by selected electro-conducting pigments based on aluminum, titan and carbon, the character of PET and PP fabrics qualitatively changed with regard to their electrical properties. This qualitative change occurred even at only 2 % pigment content on the fabric's surface, and such material showed antistatic properties.

KEYWORDS: fibre material, surface modification, electrical properties

1. INTRODUCTION

Fibre materials based on synthetic fibres are commonly used in technical fields mainly in the automobile industry. Some of requirements for fibre materials for automobiles, which are environmentally sensitive to electrostatic discharges and electrostatic fields, are their appropriate electro-conducting properties. From the point of view of electric conductivity, classical synthetic fibres are classified as non-conductors [1].

Static electricity is created by the contact between two surfaces, mainly by rubbing. At the same time, electrons are gathered, and static electricity is created on one surface, depending on electrical unit resistance of the material. Creation of static electricity may be accompanied with a creation of a flash, and this is unwanted and dangerous. In order to increase their safety, fibre materials for automobiles are functionalized by focusing on their electric properties. Methods for increasing the electro-conducting properties of fibre materials on the level of polymer substances, on the level of surfaces of fibre materials and the implementation of conducting carbon or metal pigments to the textile, respectively hydrophilisating proceedings [2,3], are well known.

Sol-gel method is hydrophilisating procedure. Its advantage dwells in a simple accomplishment and effectiveness connected to the creation of thin homogeneous layers on the polymer material surfaces [4].

Sol is an organic-inorganic composition derived from alcohols by hydrogen substitution in –C-O-H group by atom of metal (Si, Ti, Al...) or by non-metal (B,P...). –C-O-Si bond is very important for the sol-gel method due to the fact that its hydrolysis originates reactions leading to sol creation [5-7]. The addition of water and catalyst to the solution originates an operated alkoxide hydrolysis and consecutive polycondensation. Due to the polycondensating polymerizing reactions on the surfaces, a gel from sol on polymer substrate is created [7-9].

Pigments based on aluminium, titan and carbon combined with sol-gel method are used in our paper to decrease electrostatic resistance and to block the creation of electrostatic charges on the surfaces of polyethyleneterephthalate (PET) and polypropylene (PP) fibre materials.

2. EXPERIMENT

Standard PET and PP fabrics were pigmented on their surfaces. Pigments based on carbon, titan and aluminium were used from Degussa AG in Germany. Size of pigment elements is in nano and micro dimensions. Pigments were implemented into pigmenting paste.

Composition of the pigmenting paste: 1-5 % of pigment referred to fabric's weight (Printex L-6, graphite, Hombitec S-100, ALBO 615), 10 % of fixing agent (acrylate, polyvinylacetat, styrenacrylate copolymer - Sokrat 4924 AF), 10 % thickener (2 % sodium alginate in water), Novanik 1010 and Slovafol 909 wetting reagents.

Pigmenting paste was applied to PET and PP fabrics by stippling on a laboratory foulard with a 100 % wring. Fixation of the fabrics modified on their surfaces was realized by the thermal-air of 200 °C, 2 minutes or in microwave at 900 W, 0.5 minute. Consequently, the testing material was covered by the sol prepared from Si $(OC_2H_5)_4$ alkoxide and ethanol without water. Sol was applied by a dip-coating technique at a constant temperature, a constant speed of extending and at an atmospheric pressure [5]. Ensemble of the model testing samples is listed in Table 1.

Tab. 1: PET and PP fabrics with surface modification and modification conditions

Number of a sample	Type of a fabric	Type of a pigment	Type of fixation	Fixing reagent	Pigment content [%]	Fig.
A	PET	-	-	-	-	1-3
B	PP	-	-	-	-	2
1	PET	Printex L-6	microwave	acrylic	5	1
2	PET	Printex L-6	thermal -air	Sokrat	5	3
3	PET	Printex L-6	thermal -air	acrylic	1	2
4	PET	Printex L-6	thermal -air	acrylic	3	2
5	PET	Printex L-6	thermal -air	acrylic	5	1,2
6	PP	Printex L-6	thermal -air	acrylic	1	2
7	PP	Printex L-6	thermal -air	acrylic	3	2
8	PP	Printex L-6	thermal -air	PVAc	5	2
9	PET	Graphite	thermal -air	acrylic	5	1
10	PET	Graphite	microwave	acrylic	5	1
11	PET	Graphite	thermal -air	Sokrat	5	3
12	PET	Hombitec S-100	thermal -air	acrylic	5	1
13	PET	Hombitec S-100	mikrovlnne	acrylic	5	1
14	PET	Hombitec S-100	thermal -air	Sokrat	5	3
15	PET	ALBO 615	thermal -air	acrylic	5	1
16	PET	ALBO 615	microwave	acrylic	5	1
17	PET	ALBO 615	thermal -air	Sokrat	5	3

Measurement of electrical volume resistance – in order to measure electrical volume resistance of pigmented PET and PP fabrics, the flow measurement method through an object was applied at a constant one-direction voltage on a Keithley 617 Programmable Electrometer machine and TETTEX 2904/SA Guard Ring Capacitor. Working procedures were done according to STN IEC 93 norm. Volume resistance is defined as electrical resistance through the given volume unit of isolating material.

Before testing, the samples were conditioned for 24 hours at a temperature of 24°C and at relative air humidity of 32%. The surrounding temperature was 24°C.

Measurement of electrostatic charge – a Polystat PS-1 integral electrometer with a charging corona, was used in order to measure the electrostatic charge of PET and PP fabrics according to Cs patent 215536. Specific measuring parameters are following:

- maximal voltage achieved after 5 seconds of the charging corona on the textile material's surface – E_0

speed of the decline in discharging from the maximal voltage value to half of it. This time is called half-time of discharging and it is expressed in seconds – $E_{t1/2}$.

3. RESULTS AND DISCUSSION

The surfaces of PET and PP fabrics were pigmented by standard methods used during textile finishing and covered by polymer gel made of $Si(OCH_2CH_3)_4$ by using sol-gel method. Pigments were selected with a focus on reforming the electrical properties. For operative reasons, it is necessary to prevent the accumulation of electrostatic charges on textile material surfaces, respectively the electrical resistance in order to reach adequate level. Used pigments are electro-conducting.

Dependency of electrical volume resistance from the type of pigment and fixation method for the PET fabrics modified on their surfaces was evaluated and shown in Fig. 1. The dependency proves that Printex L-6 is highly efficient and it qualitatively changes the material's properties in regard to electrical resistance. Effect of the remaining used pigments – graphite, ALBO 615 and Hombitec S-100 is strongly smaller to the change of electrical properties when compared to Printex L-6. However, each pigmenting of surfaces registered decrease of electrical volume and surface resistance when compared to original unmodified PET fabric.

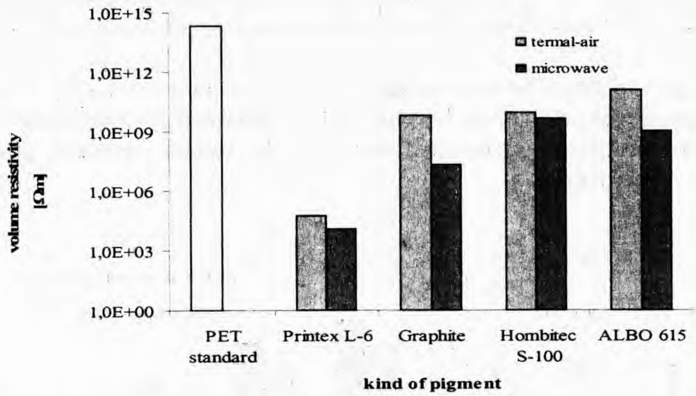

Fig. 1: Dependency of volume resistance of PET fabric from kind of pigment 5 % pigment content, fixing reagent – acrylic, fixation – thermal-air and microwave

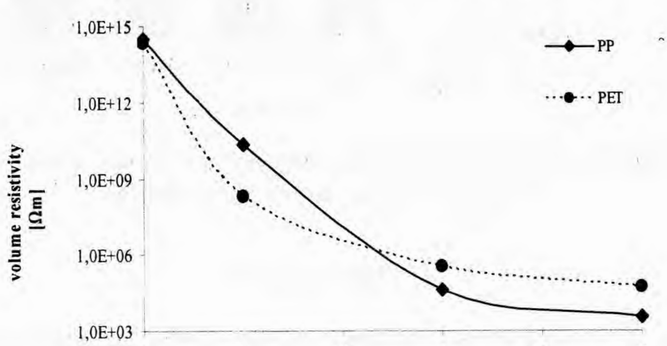

Fig. 2: Dependency of volume resistance of PET and PP fabrics from Printex L-6 content, fixing reagent – acrylic, fixation – thermal-air

Furthermore, the effect of Printex L-6 to electrostatic properties in dependence from its content on the surfaces of PP and PET fabric was evaluated. Dependency shown on Figure 2 demonstrates an important effect of the pigment content on the electrical volume resistance. Only 2 % of Printex L-6 makes the value of electrical volume resistance for PET and PP fabrics modified by pigmenting of 10^7 Ωm what corresponds with their antistatic character.

Values of the surface electrical potential measured on Polystat PS-1, Table 2, prove the antistatic character of model fabrics modified on the surfaces. Original PET sample showed a high surface voltage of 800 V and a high surface voltage of 740 V of PET sample was registered in case of sol-gel modification, too. PET samples modified on their surfaces by pigmenting showed a slight original surface potential. During the use of method of measurement the electrical charge on PET pigmented samples discharged immediately whereas PET samples without pigments registered 20 minutes long half-time of discharge.

Tab. 2: Electrical surface potential of the PET fabrics with the surface modification by pigmenting and sol-gel, content of pigments is 5 %

Sample of PET fabrics	Standard		Printex L-6		Hombitec S-100		Graphite		ALBO 615	
	Sol-gel	Without sol-gel	Sol-gel	Without sol-gel	Sol-gel	Without sol-gel	Sol-gel	Without sol-gel	Sol-gel	Without sol-gel
E_0 [V]	740	800	5	10	20	20	25	35	40	50
$E_{t\,1/2}$ [V]	370	400	0	0	0	0	0	0	0	0

Figure 3 illustrate tendency towards modest increase of these values by about 100 units. Such a modest increase preserves qualitative character of PET fabrics from their electrical properties point of view. Sol-gel modification on pigmented fabrics should restrain pigments' abrasion. This will be the subject of future experiments.

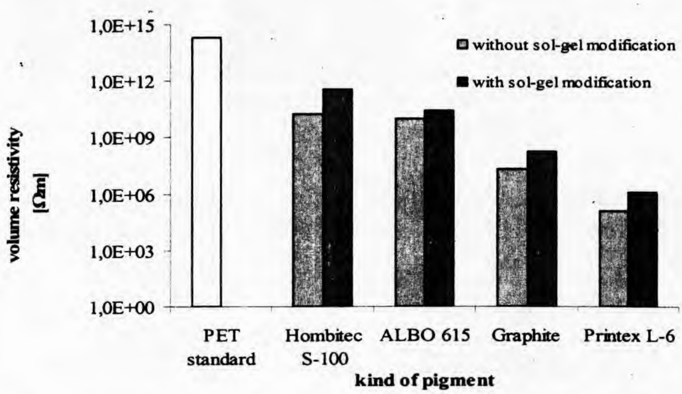

Fig. 3: Dependency of volume resistance from kind of pigment with and without sol-gel modification, thermal-air fixation, Sokrat fixing reagent

4. CONCLUSION

- Functionalization of textile materials surfaces by electro-conducting pigments is an effective way of handling their electro-conducting character.
- Printex L-6 pigment is the most effective among the evaluated pigments and even its 2% content on surface of PET and PP fabric qualitatively changes their electrical character.

- PET and PP fabrics without surface modification showed a high volume resistance, as well as high electrostatic surface potential.
- The surface modification of PET and PP fabrics by pigmenting eliminates the creation of electrostatic charge.
- The effect of sol-gel modification of PET fabrics to electrical properties of the PET fabrics is very modest.

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5. REFERENCES

[1] MILITKÝ, J.: *Textile fibres. Special fibres,* Lectures, TU in Liberec, Liberec, CZ, 2005, 75-82, ISBN: 80-7083-892-2.

[2] UYAMA, Y., KATO, K., IKADA, Y.: *Surface modification of polymers by grafting, Adv. Polym. Sci,* 1998, 137, 1–39.

[3] CHEN, Q., CHEN, W., QIAN, J., ZHANG, X., CHEN, Z.: *The research on triboelectric beneficiation of ultrafine*, Coal. Proc. Annu. Int. Pittsburgh. Coal Conf.,1999, 38–41.

[4] JASENÁK, K.: *Sol-gel methods*, UK Bratislava, SR, 2005, ISBN: 80-223-2071-4.

[5] www.solgel.com.

[6] PANDEY, P.C. and col.: *J. Sol-Gel Sci. Technol.*, 2005, 33, 25.

[7] EXNAR, P.: *Metoda sol-gel*, TU Liberec, 2006, ISBN: 80-7372-063-9.

[8] MAHLIG, B., KNITTEL, B., SSHOLLMEYER, E., BOTTCHER, H.: *J. Sol-Gel Sci. Technol.,* 2004, 31, 293.

[9] AMBERG-SCHWAB, S., KATCHOREK, H., WEBER, M., BURGER, A.: *J. Sol-Gel Sci. Technol.,* 2006, 26, 699.